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Assessment of students' lean competencies with the help of behavior video analysis – Are good students better problem solvers?

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Abstract

Engineering students are often lectured and afterwards examined in a knowledge-oriented way. The question is if the students we identify with those methods as good students are also better problem solvers in practice. To review if there is any correlation between knowledge and the development of competencies, students need to a) perform a written examination and b) solve real industrial tasks at the Process Learning Factory CiP like rebalancing a production line. Regarding a), students gain the theoretical knowledge in a classroom lecture to the topic „Lean Production" and write an exam. Regarding b), videos recorded showing the actions tasks are evaluated regarding the presence of problem solving competencies. A comparison of the test results and the action tasks evaluation clarifies whether the existence of knowledge leads to a similar strong development of competencies. The evaluation of the learning success shows that the student groups achieve a good and very good competency development in the lecture modules "line balancing", "kanban" and "systematic problem solving". The respective lecture module is confirmed by a high degree of students' success. However, a correlation between the level of knowledge and competency cannot be clearly established because on the one hand students with good exam results achieve a good and very good degree of competency development. On the other hand students with a bad exam result achieve nevertheless a comparatively good competency development degree. Nevertheless, as a trend it can be confirmed that consolidated knowledge is one important prerequisite for the ability to act in practice.

Keywords: production management; learning factories; knowledge evaluation

1. Introduction

After graduation engineering students are about to work in an environment where short innovation- and product life cycles, fluctuating markets and scarce resources, to name just a few examples, require a flexible, cost-effective and competitive business strategy [1]. The execution of such strategies requires a profound knowledge of modern lean production systems with their objectives to minimize waste and increase flexibility [2].

Prerequisite for a successful implementation of lean production systems is a well-founded knowledge of the employees, the ability to integrate new knowledge, to gain systematic problem solving skills and thereby actively accompany continuous improvement measures [3,4].

However, in education of engineers in general and of industrial engineers in specific, most times students are prepared for those industry requirements with traditional lectures in which they learn about continuous improvement, TPS, etc. from a theoretical and strongly knowledge-oriented point of view. Additionally, in exams rated "good" or "excellent" students are the ones that are able to answer solely knowledge-oriented exam questions. Even though there are teaching approaches which focus on both teaching of students and employees [5,6], when students go into industry it's still not clear if those "good students" are prepared to solve problems in industrial environments. The question explored in this paper is: Are good students better problem solvers?

This is done with the help of an evaluation concept for the course "Lean Production" at TU Darmstadt. The evaluation concept is based on a prototypical video analysis guideline [7]

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and the use of action tasks for evaluation in learning factories [8]. The study examines a possible correlation between the level of knowledge, performance in real problem situation, and consequently the respective competencies of students.

2. Theoretical principles

2.1. Competency development

Erpenbeck und Rosenstiel describe competencies as „dispositions of self-organized action“ [9]. According to Rosenstiel the concept of disposition reflects a basic talent and a potential, which will be developed by dealing with the problems arising from environmental requirements. Competencies are therefore resulting from decision-making self-organization dispositions. They enable the individual to solve complex and situational problems reflectively and creatively [9].

In order to systematize the competencies, Erpenbeck and Rosenstiel believe that the self-organized dispositions always move within a region of actions that reflect the relationship of a subject to another subject or object [9]. From the consideration of these relationships result the following four competency classes: Personal competencies, activity- and implementation-oriented competencies, technical and methodological competencies, socio-communicative competencies. For explanation on the competency classes see [10,11]. In this paper only technical and methodological competencies are evaluated.

The following statements on the competency concept are crucial in the context of this paper (assembled by Hertle et al. [12]): Because of the fact that competencies itself cannot be observed, it is important to disassemble them to single actions or “performances” [13] in specific situations. It is not possible to align them directly to an action because other aspects like knowledge need to be taken into consideration as well [9]. Knowledge itself is a prerequisite to act independently in unknown problem situations [9,14,15]. As competencies, knowledge can as well be distinguished between professional (general expertise and process knowledge) and conceptual knowledge which are both required for the development of a competency [14].

Learning factories offer a great potential for developing production system-relevant competencies by letting employees experience and test the lean transformation process [11]. In learning factories, competencies are developed through practical training in a realistic production environment to solve complex problem situations by self-organized and creative actions on the basis of professional and conceptual knowledge [10]. Thus, the training participants are prepared for a wide variety of challenges in their daily work.

In order to meet the learning objectives, learning factories and respective learning modules should be designed in a competency-oriented way. A systematic approach including two didactic transformations in which the reciprocal relationships between key objectives (intended competencies), knowledge, learning factory processes and products, and the (formal, non-formal, and informal) learning processes are analysed, described, and designed systematically [16,17].

Table 1. Competency transformation table (example)

Competency	Sub-competency	Correspon-ding action	Professional knowledge	Conceptual knowledge
Line balancing	1.1 The participants are able to reflect the success of their line balancing	The participants define quality indicators	Cycle time, productivity, rework rate…	These metrics are used to describe the quality of production
	1.2 …	…	…	…

The interface between the two didactic transformations forms a “competency transformation table” [16] (see table 1), which is a result of the first didactic transformation. With the help of the table the organizational requirements of the learning factory operator, the targeted work systems and the learning factory target group are conciliated with the relevant learning factory contents. By that intended competencies are generated which are the learning objectives [16,18]. Detailed concretization of these competencies takes place through the allocation of sub-competencies and actions. The actions align with corresponding knowledge including professional (consisting of general expertise and process knowledge) and conceptual knowledge elements [14].

Thus, in the transformation a link between actions (or performances), knowledge, competencies, and subordinated sub-competencies are drawn. Based on the competency transformation, in the second didactic transformation, the conceptual implementation of the learning factory system takes place [16–19]. In this paper the included information in the competency transformation are not used to design but to evaluate the competencies of students by evaluating the students’ knowledge and their ability to act in unknown problem situations; on that topic see also [8].

2.2. Lean production

The methods and principles of lean production attracted worldwide attention first through the Toyota production system, called TPS. Since then, they are used and adapted increasingly for the design of efficient production processes [4,20]. The central aspect of lean production is to avoid waste, respectively all that is not used directly for the value added of products. With regard to the topic of this work the lean methods line balancing, Kanban and systematic problem solving are described briefly.

Starting from the demand prognosis for a certain period, the task of line balancing is to adjust the actual production cycle of the calculated customer takt time by adapting the assembly steps and cycle times. For production lines, this means that the work content needs to be distributed on the basis of the takt time to a corresponding number of employees. In addition to reducing waste, this results in a more flexible staff deployment [20].

Kanban is a closed loop system, which underlies the linking of a backward-moving information flow chain with a forward-